Clinical Neurophysiology 126 (2015) 297–303

Contents lists available at ScienceDirect

Clinical Neurophysiology

journal homepage: www.elsevier.com/locate/clinph

Development of the posterior basic rhythm in children with autism

Kentaroh Takagaki [a,b,*], Jean Russell [c], Michael T. Lippert [a,d], Gholam K. Motamedi [c,e]

[a] Leibniz-Institute for Neurobiology, 39118 Magdeburg, Germany
[b] Department of Internal Medicine, Georgetown University Hospital, Washington, DC 20007, USA
[c] School of Medicine, Georgetown University, Washington, DC 20007, USA
[d] Otto-von-Guericke-University, 39118 Magdeburg, Germany
[e] Department of Neurology, Georgetown University Hospital, Washington, DC 20007, USA

ARTICLE INFO

Article history:
Accepted 23 April 2014
Available online 27 May 2014

Keywords:
Autism
Electroencephalography
Development
Posterior basic rhythm
Alpha
Resting state

HIGHLIGHTS

- We quantitatively modeled development of the posterior basic rhythm in children.
- Compared to normal children, a subset of autistic children has an earlier maturation of the posterior basic rhythm, especially in the 2- to 4-year old age range.
- Autistic children also show a distributed decrease in band-limited coherence of the posterior basic rhythm.

ABSTRACT

Objective: Early detection of autism is critical for effective intervention, but currently, no simple screening tests are available. Furthermore, little is known about the development of brain dynamics in young children. We examine the early neurophysiological manifestations of autism by retrospectively analyzing EEG. In particular, we focus on maturation of the posterior basic rhythm (PBR), which is one of the most characteristic features of the normal EEG, and comprises a discrete functional state.
Methods: Subjects with a diagnosis of autism ($n = 74$), as well as normal ($n = 134$) and epileptic ($n = 108$) controls, were extracted retrospectively from our digital EEG database. Segments with clear PBR were extracted, and standard signal analysis methods were used to calculate peak PBR frequency, power, and coherence.
Results: In our cohort, a subset of autistic children show accelerated development of the PBR, with early maturation especially in the 2- to 4-year old range. The overall coherence of PBR-specific activity is also lower in autistic children in our cohort.
Conclusions: These findings provide evidence that autism is associated with accelerated development of the PBR.
Significance: These findings generate a clinical hypothesis for future prospective studies on the efficacy of these simple measures as a diagnostic or screening tool.

1. Introduction

The prevalence of autism and autistic spectrum disorders is thought to approach 1% (Autism and Developmental Disabilities Monitoring Network Surveillance Year 2006 Principal Investigators, 2009; Baron-Cohen et al., 2009), but the underlying pathophysiology is yet unclear. Recently, attention has been directed to the "connectivity hypothesis," whereby the autistic brain is thought to have aberrant white matter tracts. This hypothesis was inspired by observations of abnormal anatomical development of head circumference (Kanner, 1968) and white matter (Herbert et al., 2004) in autistic children, and posits that underconnectivity leads to less integration of information, and more posterior autonomy in sensory processing (Just et al., 2012). Functional results suggestive of this hypothesis have been obtained from resting state

* Corresponding author at: Department Systems Physiology of Learning, Brenneckestraße 6, 39118 Magdeburg, Germany. Tel.: +49 391 6263 94391; fax: +49 391 6263 95489.
E-mail address: kentaroh.takagaki@lin-magdeburg.de (K. Takagaki).

http://dx.doi.org/10.1016/j.clinph.2014.04.022
1388-2457/

fMRI, MEG, resting state EEG and event related potential (ERP) recordings.

In order to investigate developmental dynamics and connectivity of the EEG, we focus here on the posterior basic rhythm (posterior dominant rhythm, PBR) (Berger, 1929). The PBR is one of the most characteristic features of the normal EEG. It is most prominent in the occiput, and is strongest during quiet wakefulness, with eyes closed. It appears stably at around 3 months at around 3–4 Hz, and accelerates to the adult range of around 10 Hz by approximately 10 years old (Kellaway, 1990). We focus on PBR for three main reasons: Firstly, the developmental time course of PBR coincides with the time during which signature pathological events of autism are thought to occur. Secondly, it is a discrete resting state which is robustly present in most EEG records with high signal-to-noise ratio. Thirdly, EEG results from adult and aging patients suggest that PBR is associated with cognitive performance (Klimesch, 1999; Sauseng et al., 2009).

Table 1
Subject characteristics.

Parameter	Normal	Autistic	Epileptic
Number of children	134	74	108
Males, $n = 207$	83	64	60
Females, $n = 109$	51	10	48
Age			
0–2 years old	17	0	8
2–4 years old	20	28	18
4–8 years old	44	26	52
8–16 years old	53	20	30

2. Methods

2.1. EEG database and data acquisition

Digital EEGs from 93 autistic individuals were identified by retrospectively searching the EEG database at Georgetown University Hospital. Only children 0–16 years old at the time of acquisition were included. Included studies were conducted between March 2003 and May 2012. As controls, 134 normal children and 108 epileptic children were also identified. Diagnoses were corroborated by review of clinical charts and referral materials. Nineteen subjects were both autistic and epileptic according to our definitions, and were removed from the database to simplify statistical analyses, leaving 74 autistic subjects. Our retrospective design allowed us to obtain a large cohort of patients in the early developmental period, which may be a key to understanding autistic pathophysiology (Courchesne et al., 2007; Dinstein et al., 2011).

Most of our autistic patients were referred for a routine screen for epileptiform activity, without any clinical seizures. Our normal children were typically referred to evaluate abnormal motor or

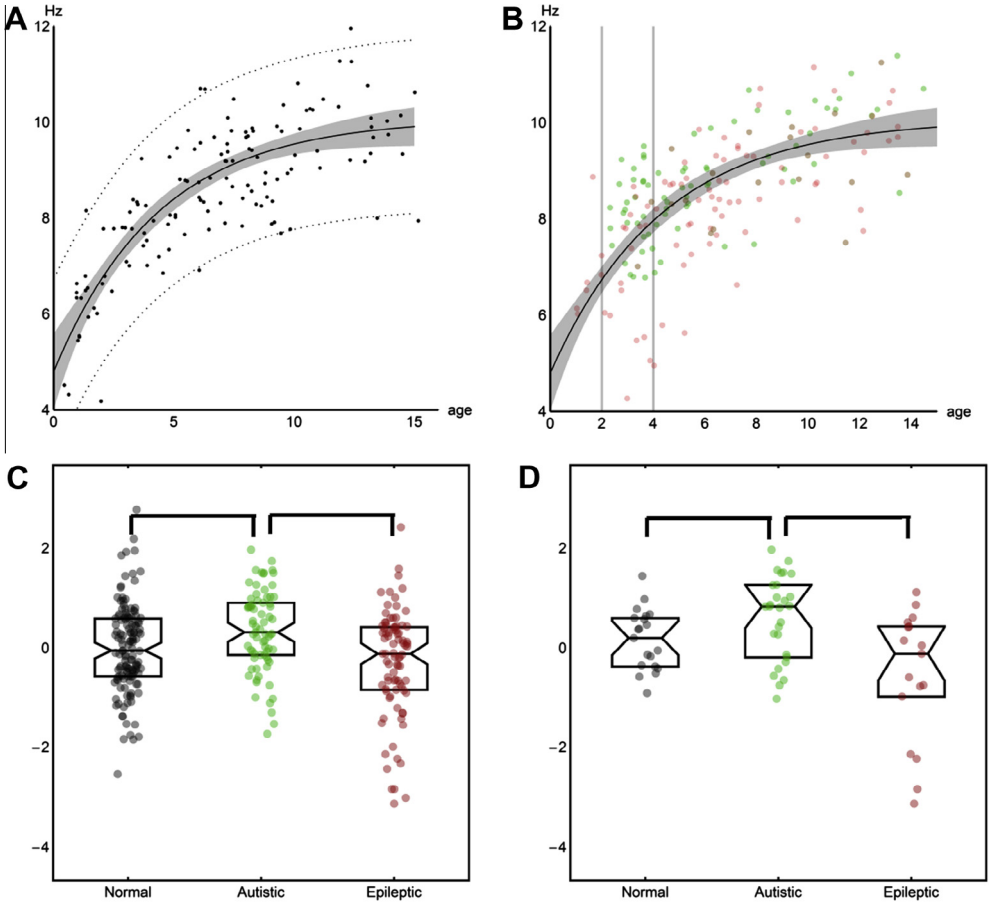

Fig. 1. Posterior basic rhythm (PBR) development in children, A. Each dot represents individual data points ($n = 134$) of the mean PBR frequency of normal children. Shaded region indicates the 95% mean prediction interval for this nonlinear model fit, and dotted bounds indicate the 95% single sample prediction interval. B. Green dots indicate autistic children, red dots indicate epileptic children. Brown dots indicate children who fall into both classes. C. PBR frequencies for the three subject groups, corrected by the nonlinear fit function in A. Each point represents one subject, with quartiles overlaid with boxes. Based on pairwise Kruskal–Wallis tests with a p-value cutoff of 0.05, significant differences are seen between the normal and autistic children and between autistic and epileptic children. D. The same differences are seen for the subset of 2- to 4-year olds.